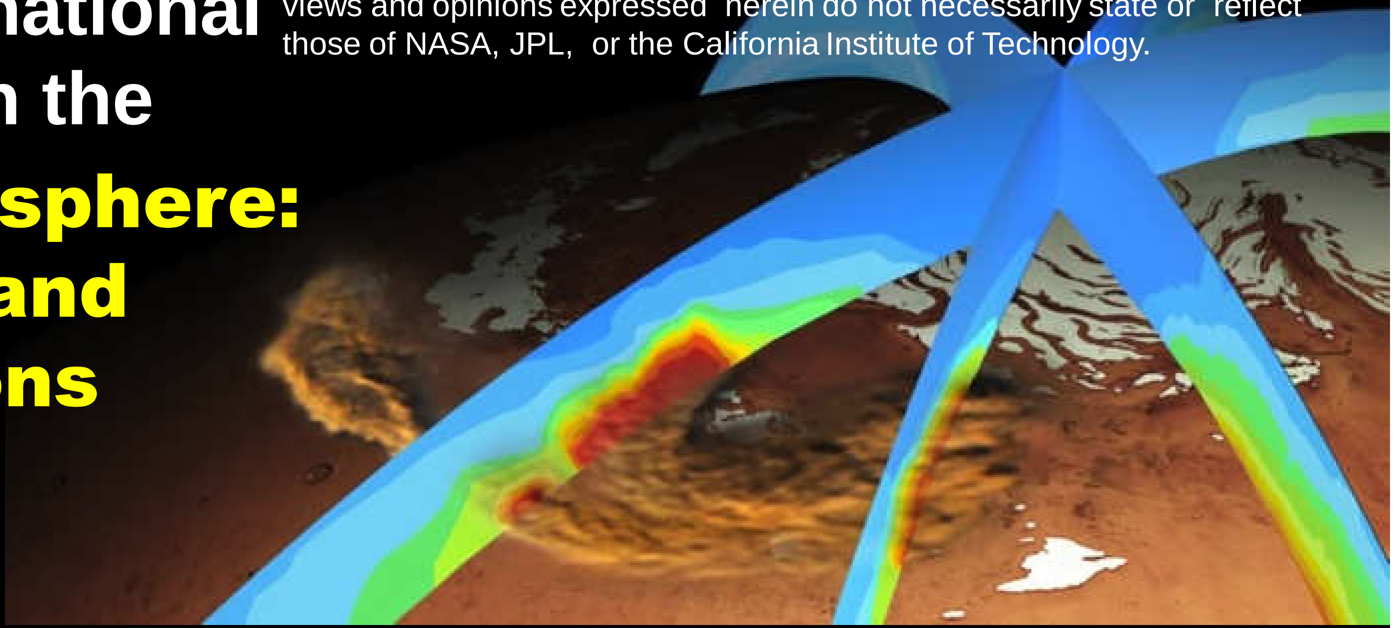
Fourth International workshop on the Mars Atmosphere: modelling and Observations

François Forget

LMD, Paris, france



Picture : **SOAR project - D. Goods – M. Mischna- M.** Allen - JPL

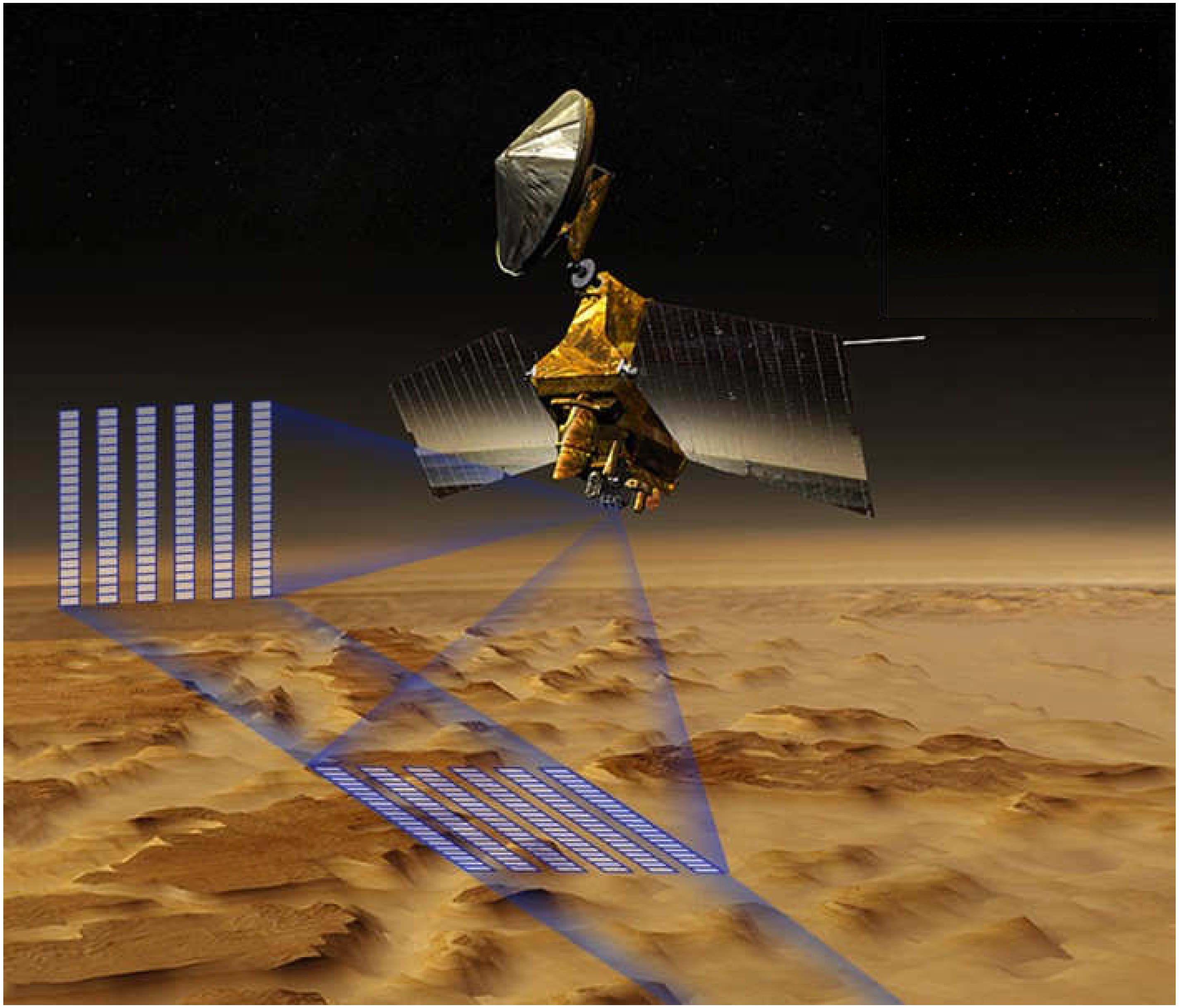
- ***February 8 – 11, 2011 Paris, France***
- **http://www-mars.lmd.jussieu.fr/paris2011/**
- **~150 participants. 138 contributions.**

Fourth International workshop on the Mars Atmosphere: modelling and Observations

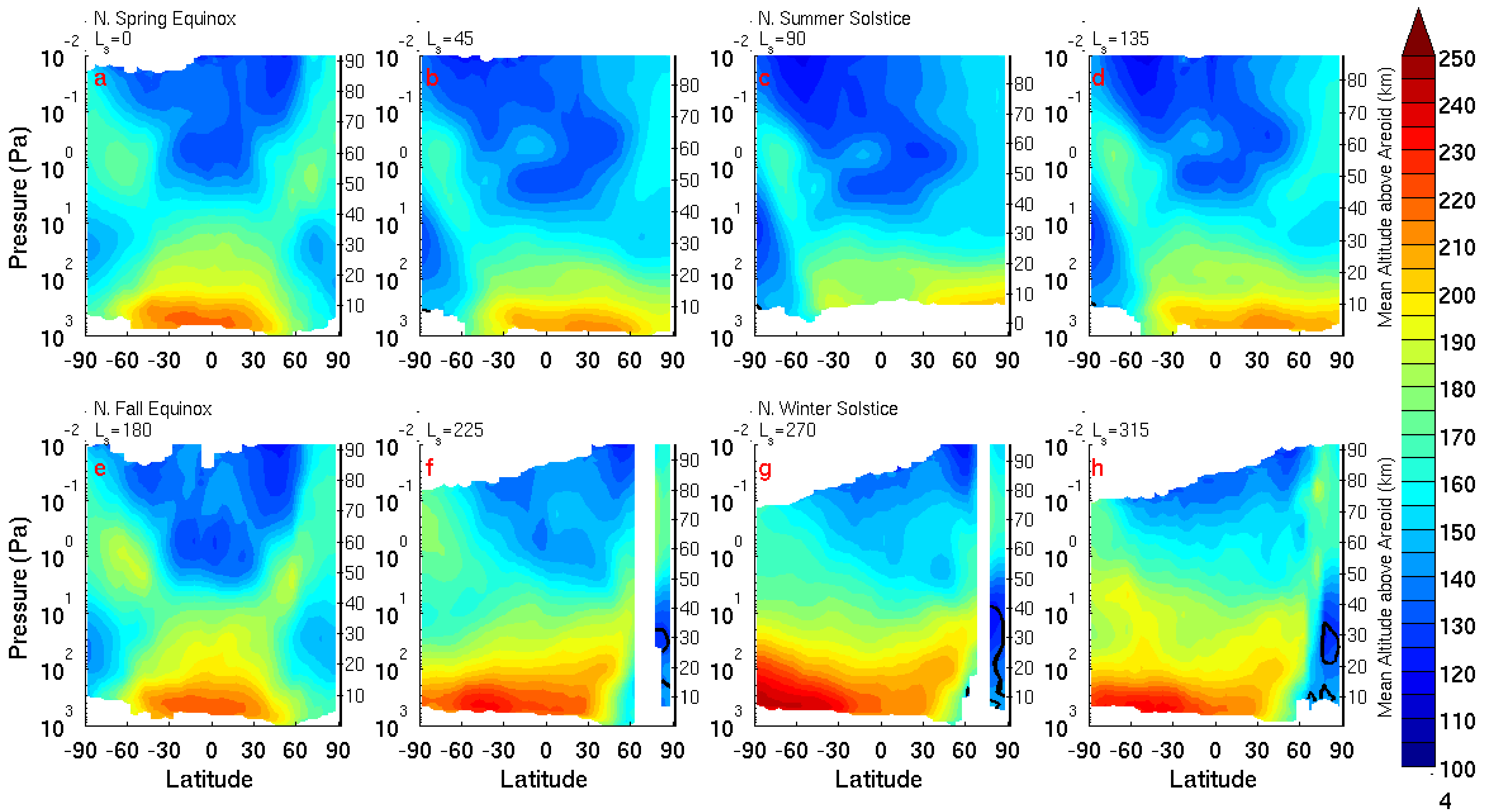
Sessions:

- Mars Climatology: new observations and data assimilation
- Modelling the atmosphere at various scales
- Dust storms and waves
- Mars vertical distribution of aerosols revealed
- More and water ice clouds
- Polar caps and Frosts
- Photochemistry
- Upper atmosphere and Ionosphere
- CO_2 ice clouds
- Past climates
- Future observations

Mars Climate Sounder (Mars Reconnaissance Orbiter)



Atmospheric Temperature
Zonal Average
Nightside

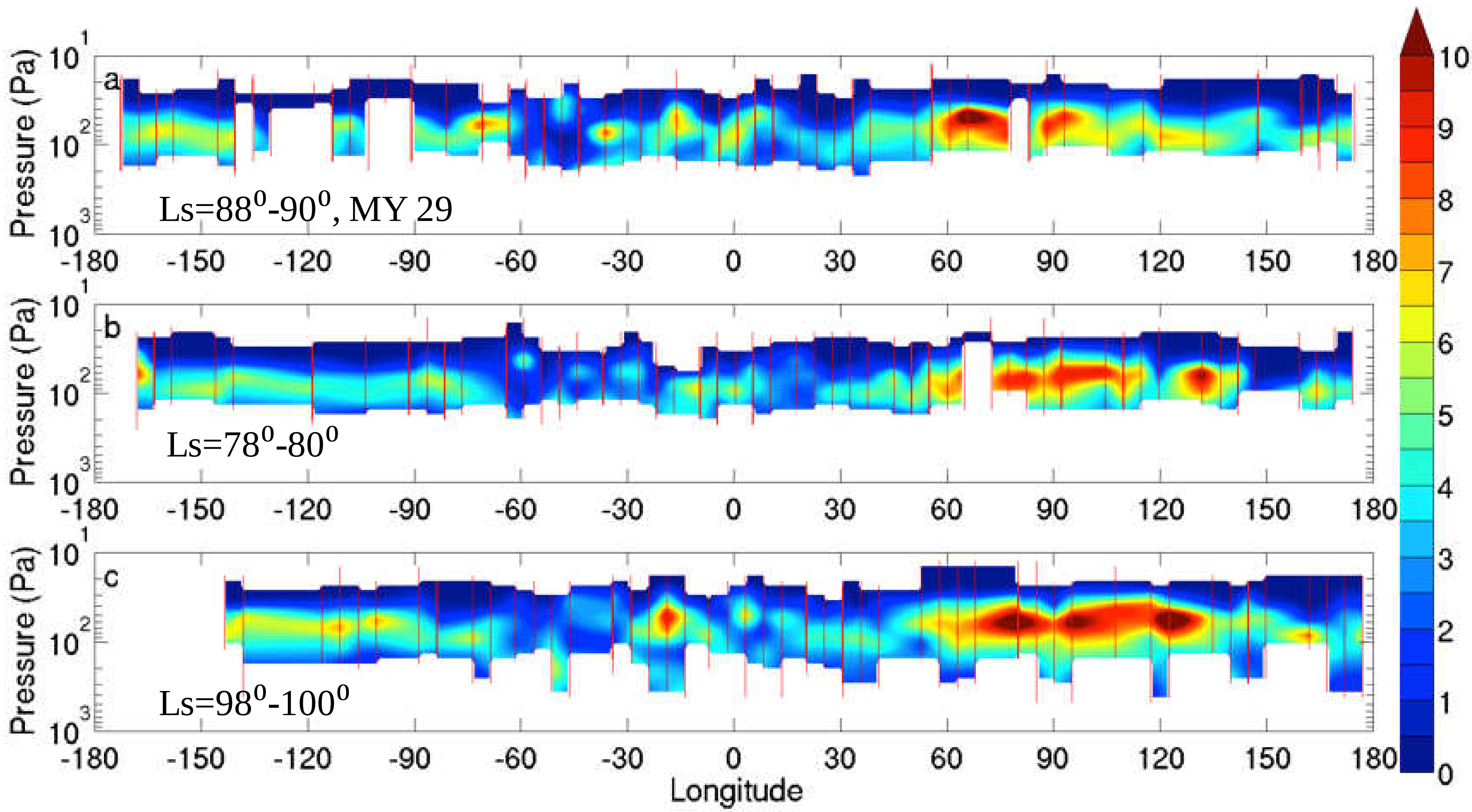


McCleese, et al. (2010)

Atmospheric Dust during the aphelion (cloudy season)

Density-scaled Opacity – Nightside

Longitudinal Cross-sections (24.3^{0}N - 26.3^{0}N)

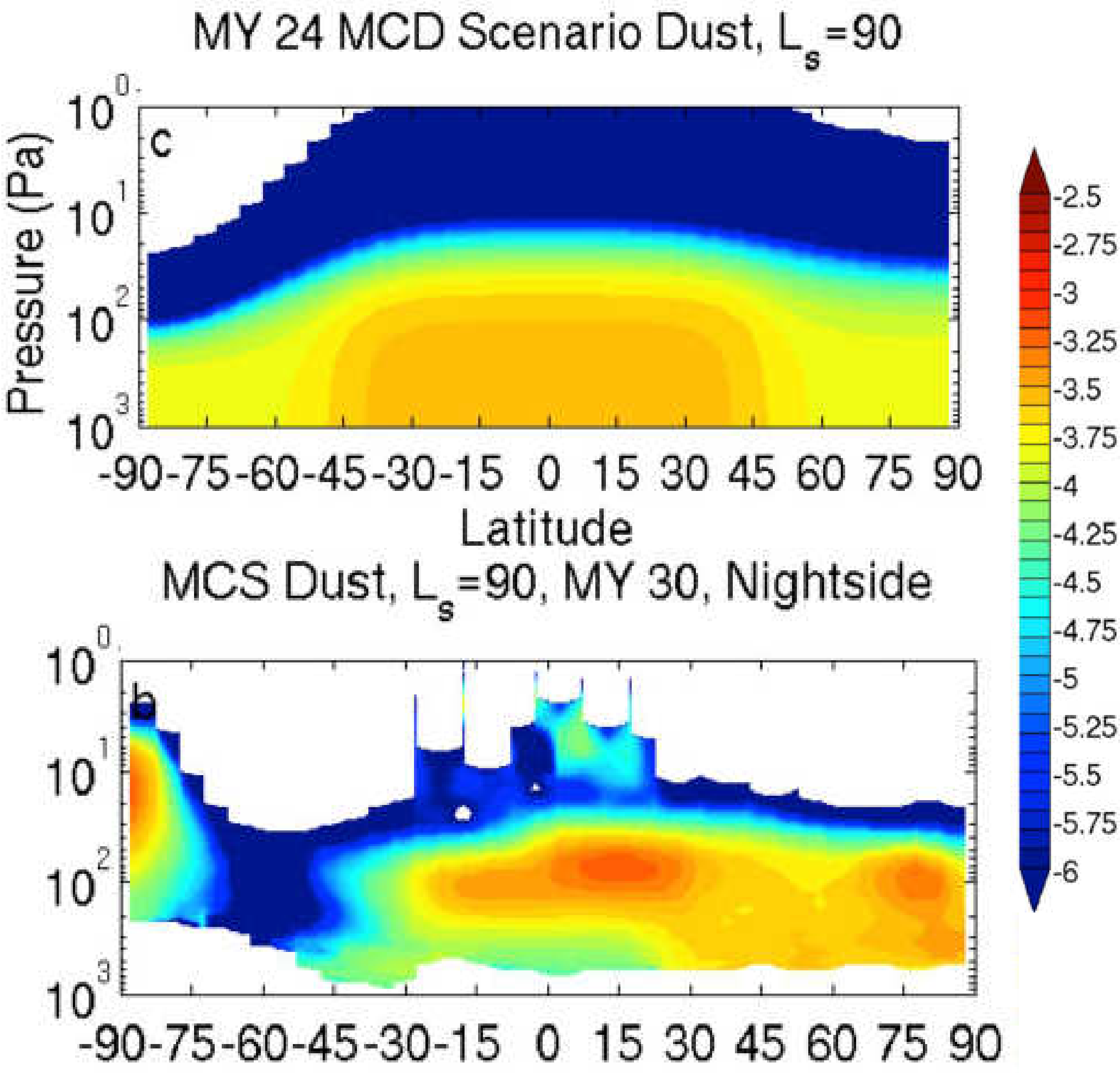


Heavens, et al. (2010)

Dust density scaled opacity ($m^2 kg^{-1}$) during the aphelion season observed by MCS *(Heavens et al. 2011)* **(log units)**

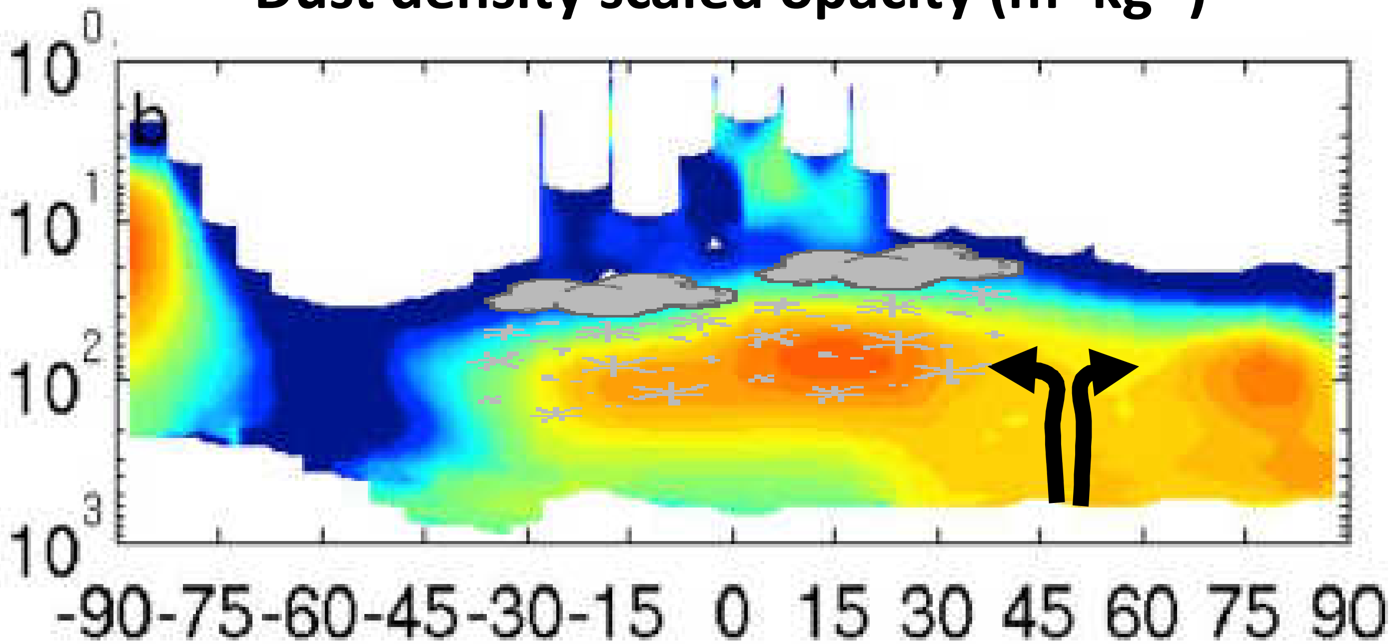
Expected distribution *Forget et al. 1999*: **(well mixed)**

Distribution observed by Mars Climate sounder (enriched layer)



On ongoing debate: what is the process forming detached dust layers

Dust density scaled opacity ($m^2\ kg^{-1}$)

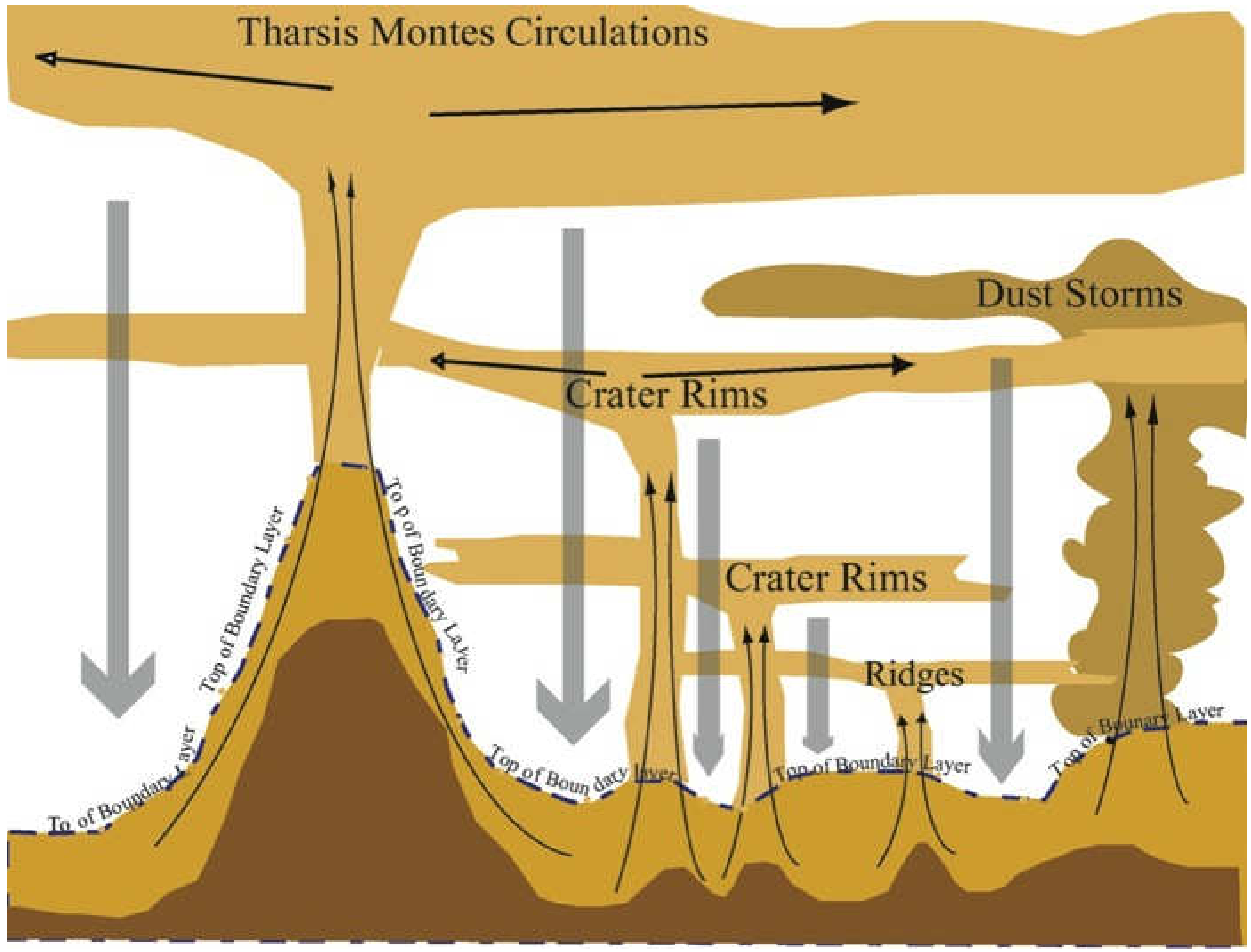


1) Dust enrichment below dust scavenging clouds

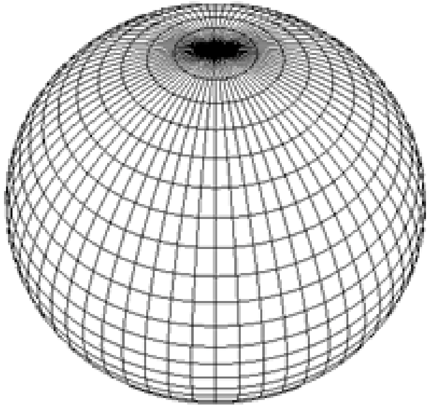
2) Direct transport of dust from the boundary layer to the mid atmosphere by Local topography circulation

“Non-Local Deep Transport” (Rafkin et al.)

- Winds and dust devils lift dust into the boundary layer.
- Local topographic circulations transport dust out of the boundary layer into the free atmosphere.
- Regional circulations also transport dust to preferred regions of large-scale ascent.
- This process should also operate for water and other species (e.g., CH_4).



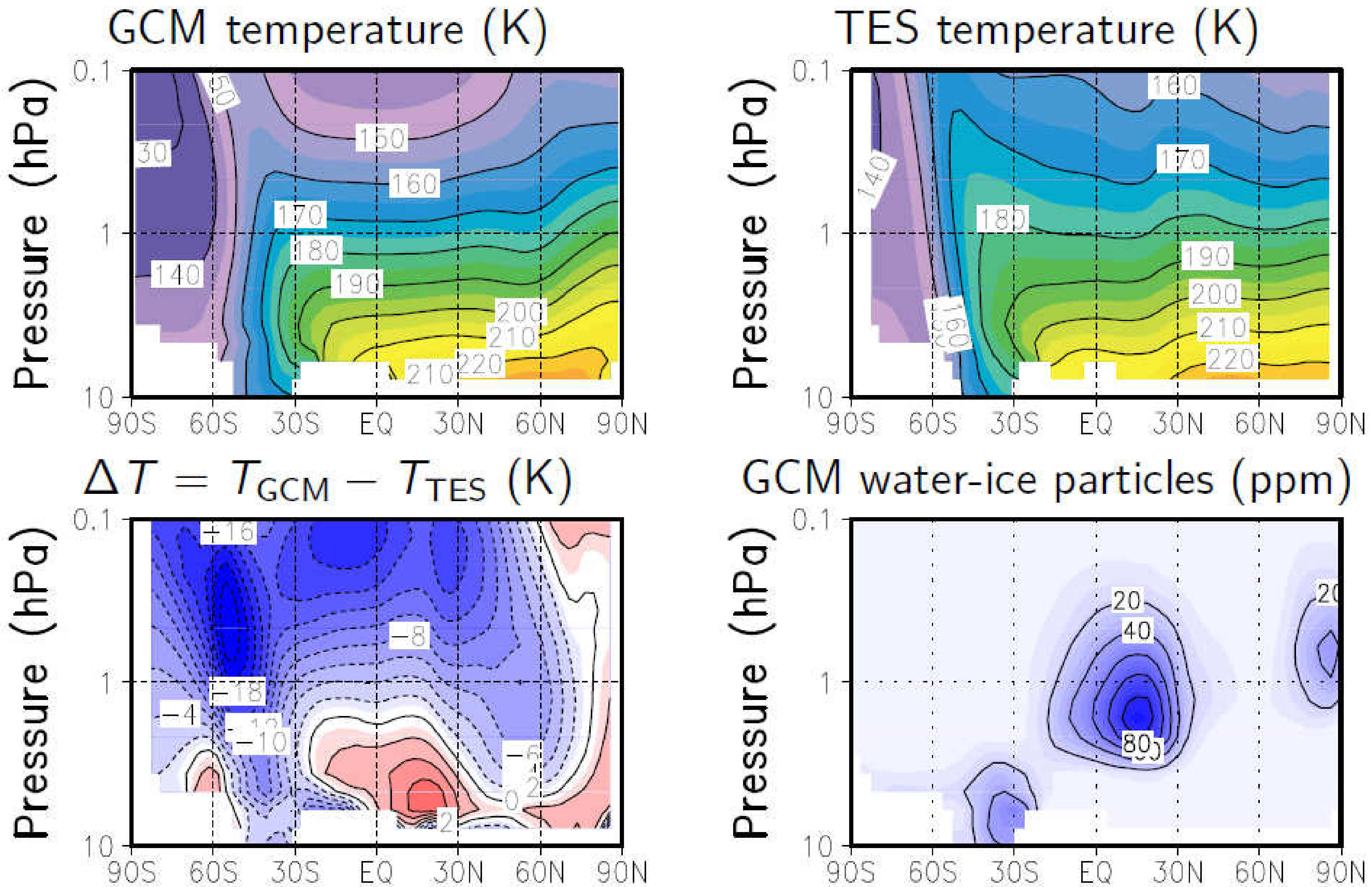
A flow of simultaneous results on the radiative effect of water ice clouds



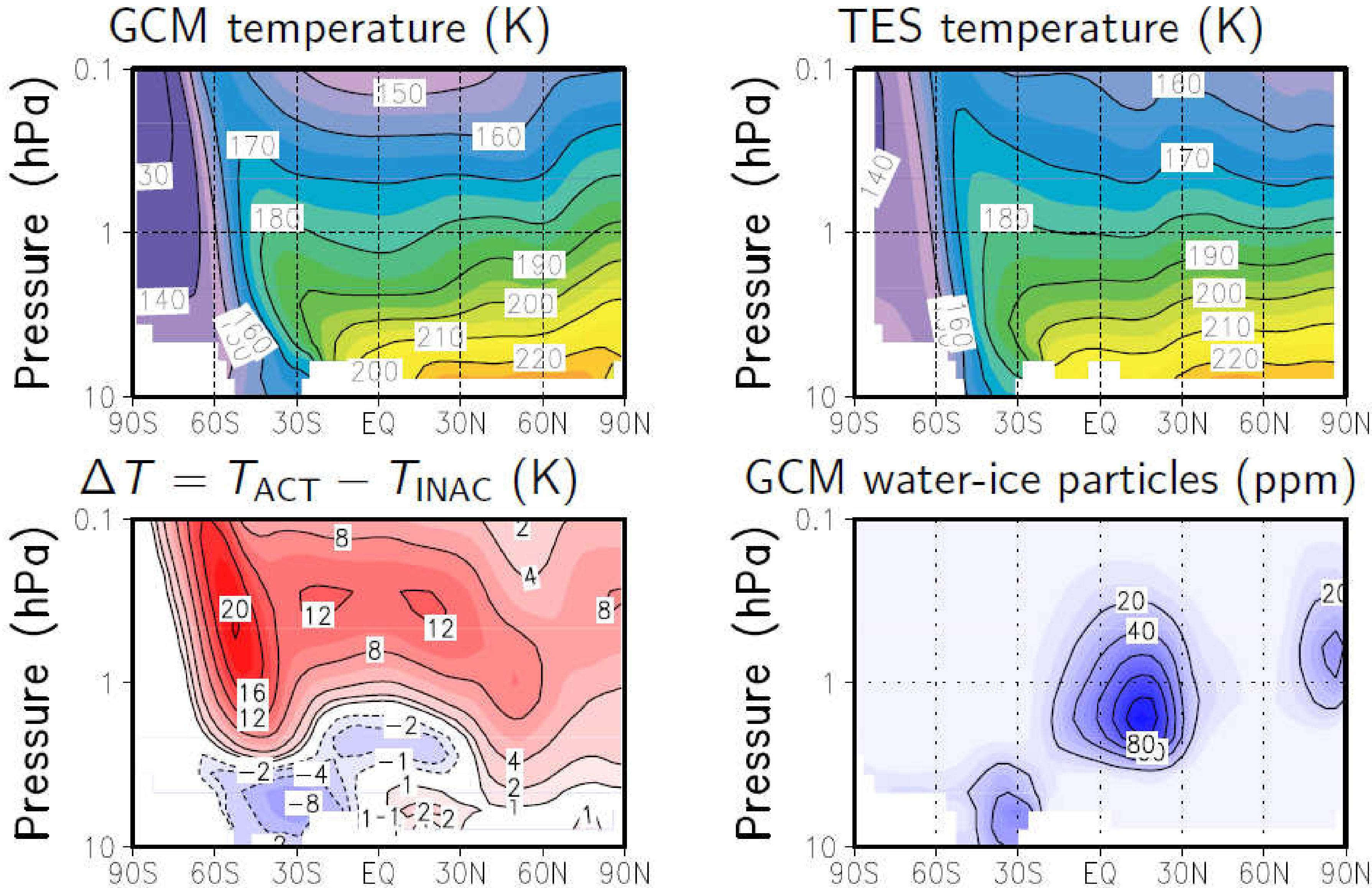
Until recently, the radiative effect of water ice clouds was neglected in most climate models. It is now taken into account and analyzed in most major models

- GFDL (Wilson et al.)
- NASA Ames (Haberle et al., Kahre et al.)
- LMD (Madeleine et al., Forget et al., Read et al.)

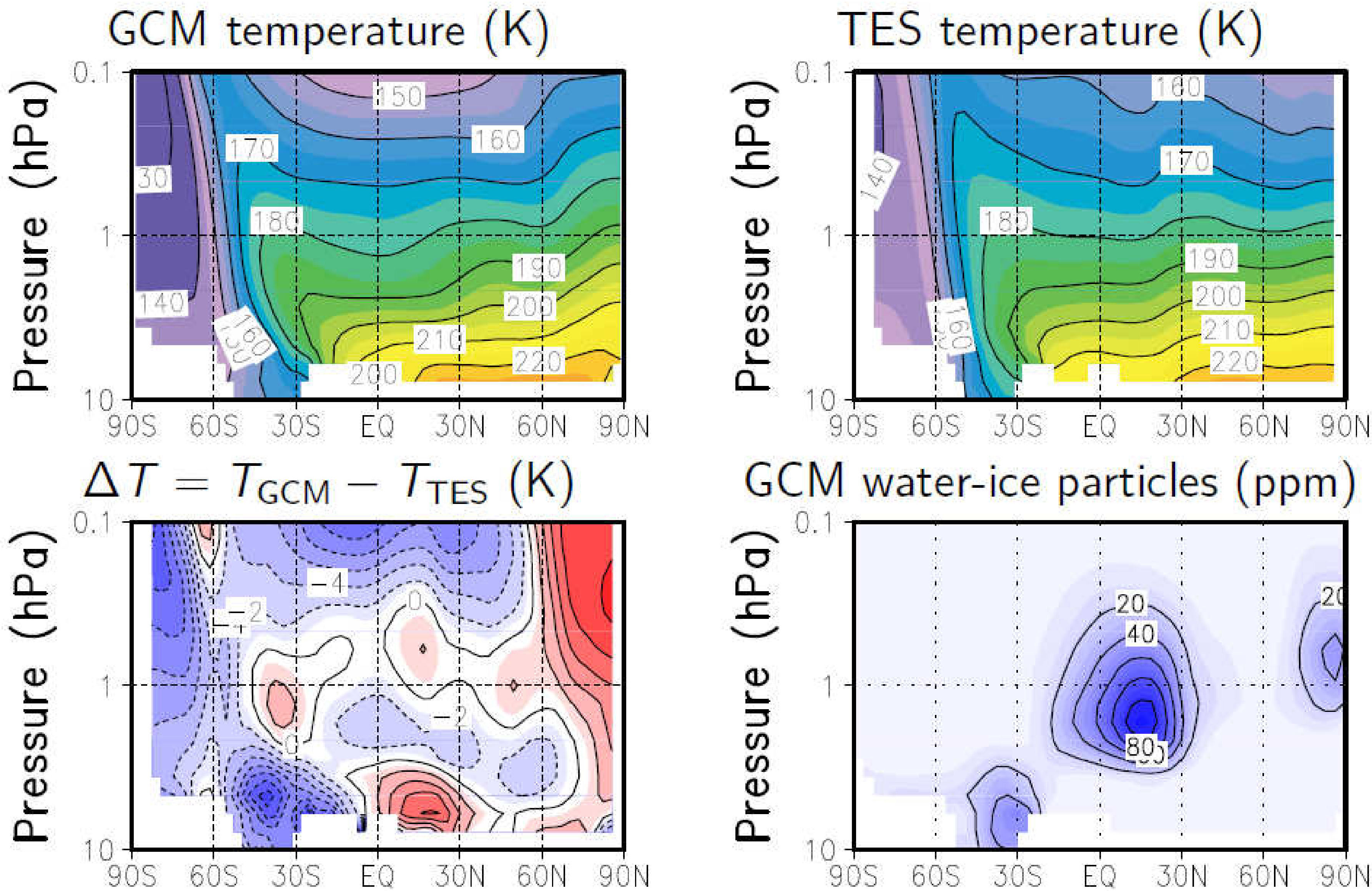
Temperature without active clouds ($L_s = 90°$)



Impact of clouds on temperature ($L_s = 90°$)



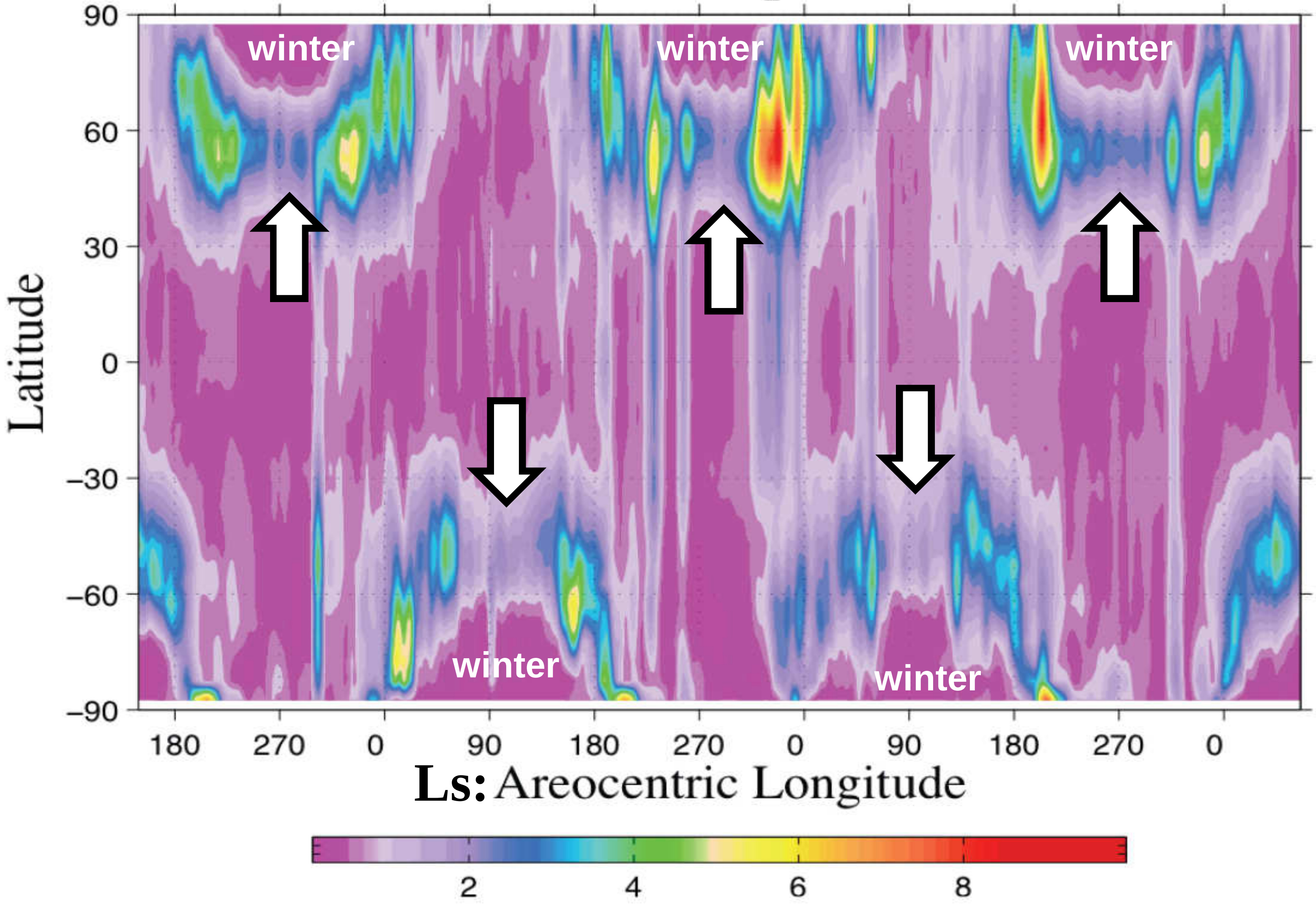
Temperature when clouds are active ($L_s = 90°$)



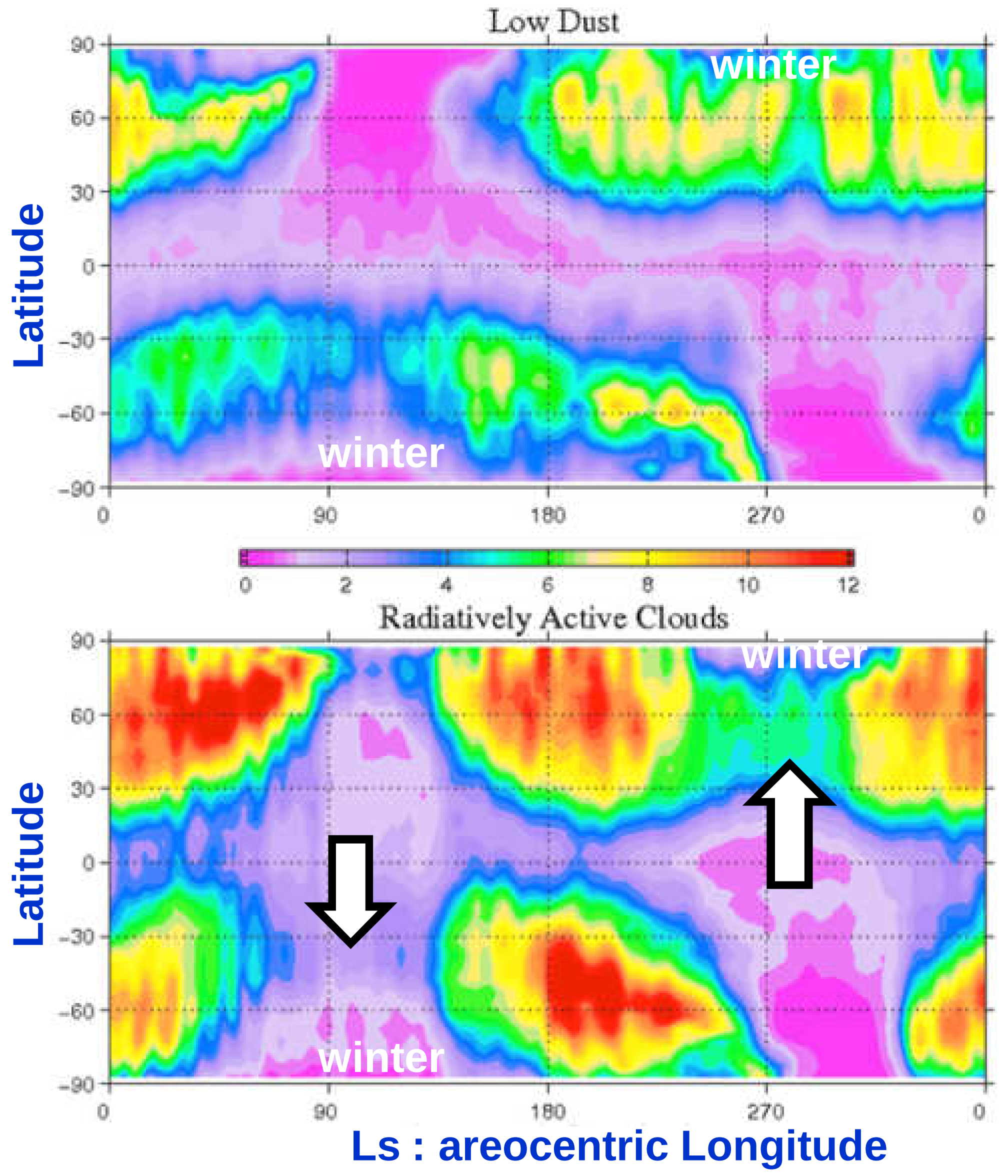
Cloud explain the enimatic "solsticial pause" of winter storms and eddies *(Read et al.)*

Transient Eddies intensity:

Standard deviation of transient eddy temperature at the 4 hPa level as represented in the UK Mars reanalysis of TES observationsfor MY24-26.



Influence of Water Ice Clouds on Transient Eddy Activity

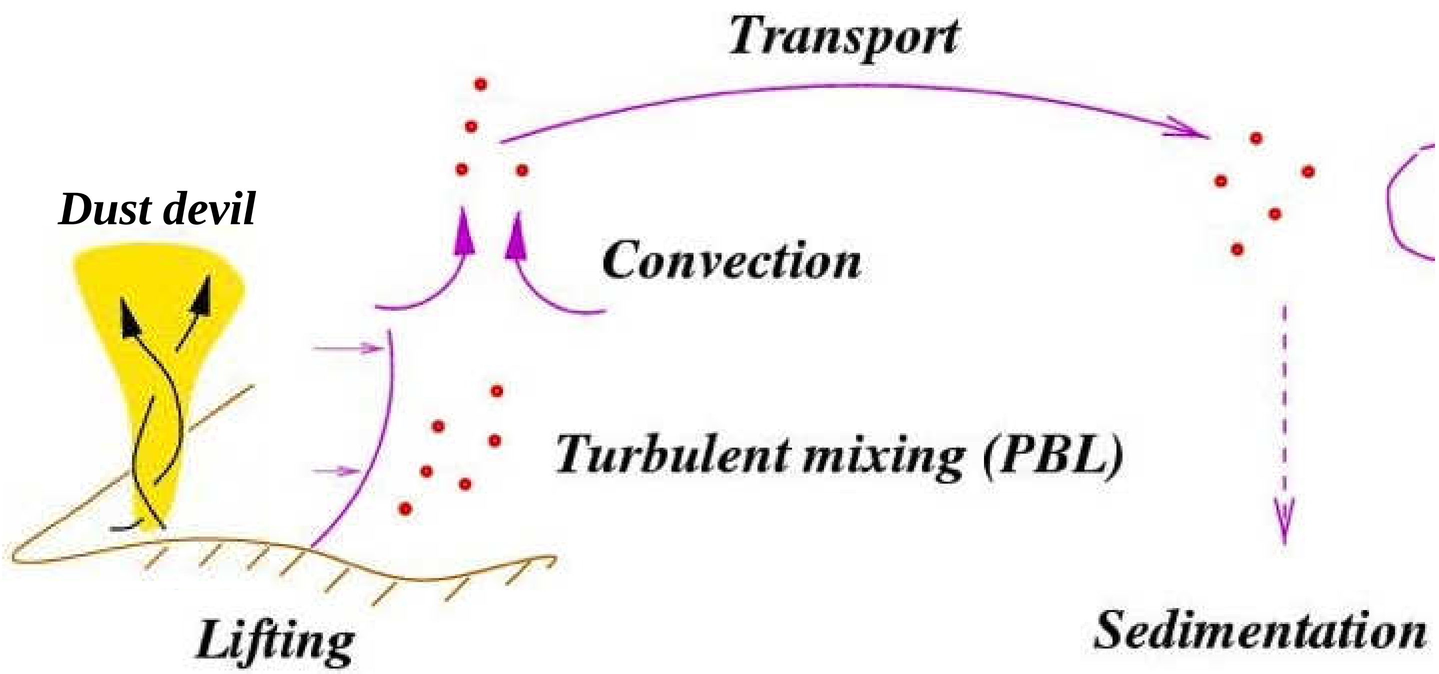


Fixed (low) Dust;
Passive Clouds

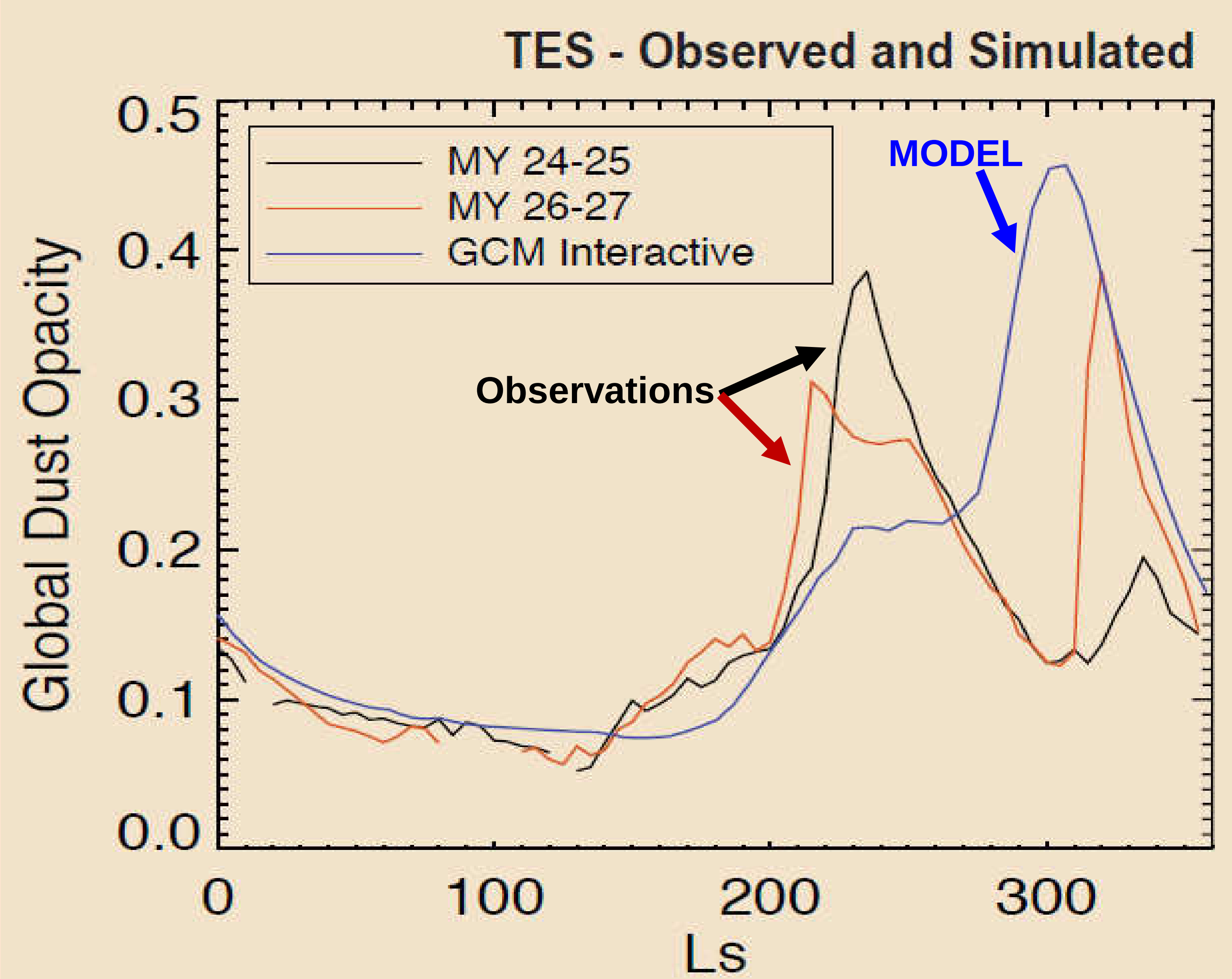
Radiatively Active Clouds

Wilson et al.

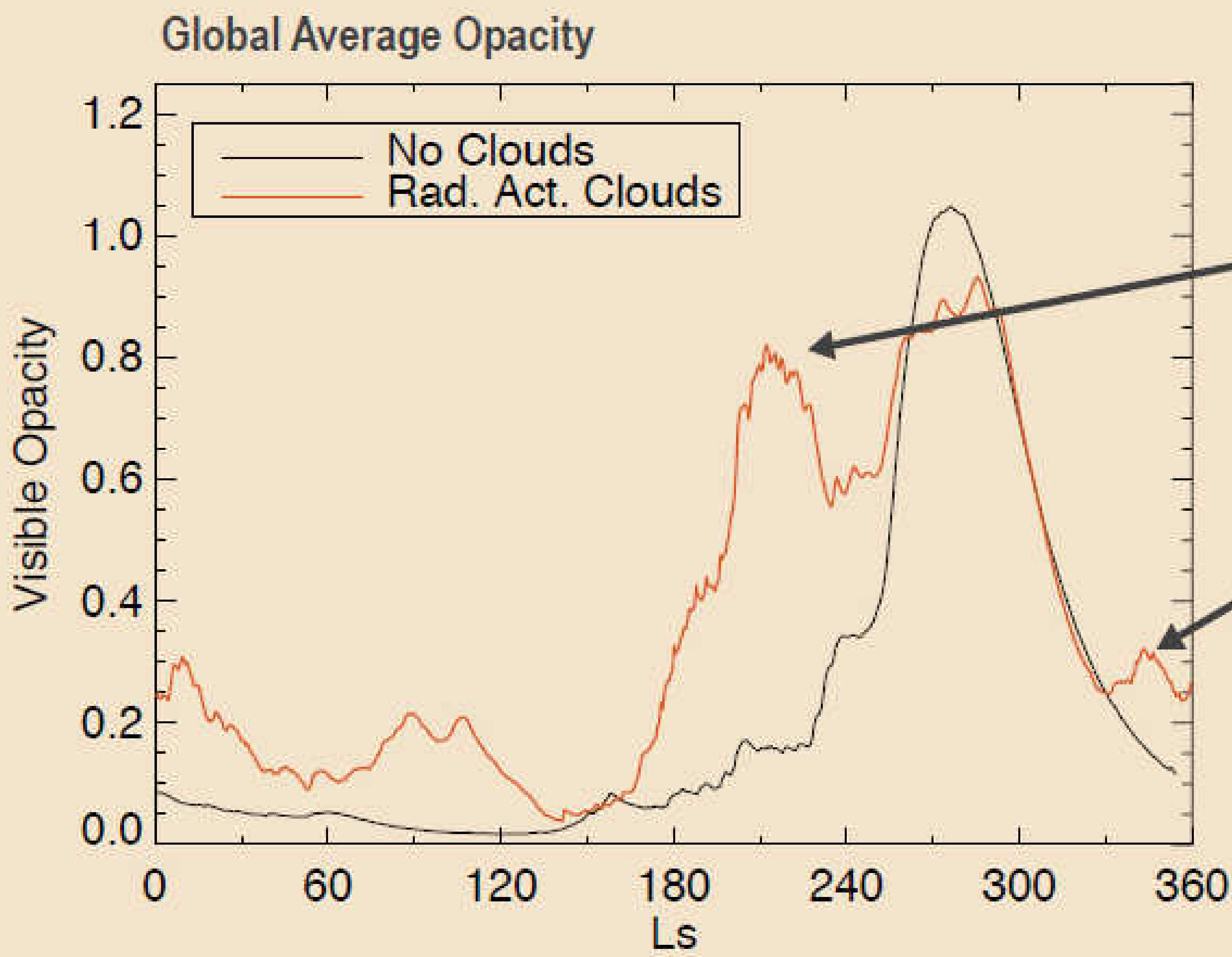
Impact of clouds on the dust cycle !



Dust cycle as simulated by Kahre et al. (NASA Ames)

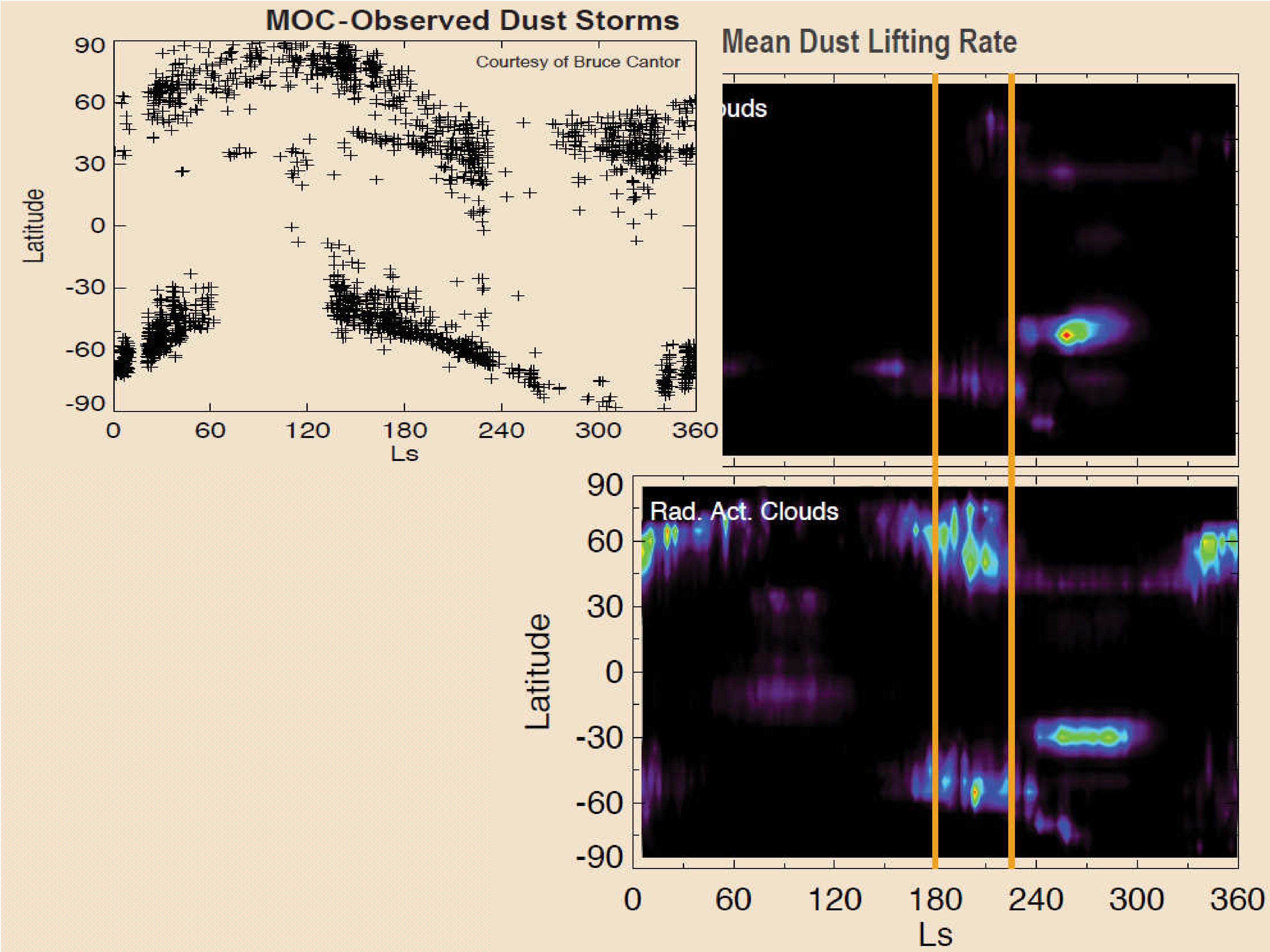


Simulation with radiatively active clouds (Kahre et al.): consistent with the observations

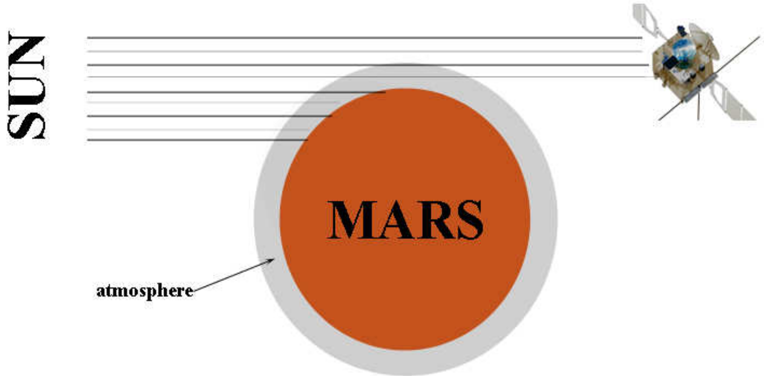


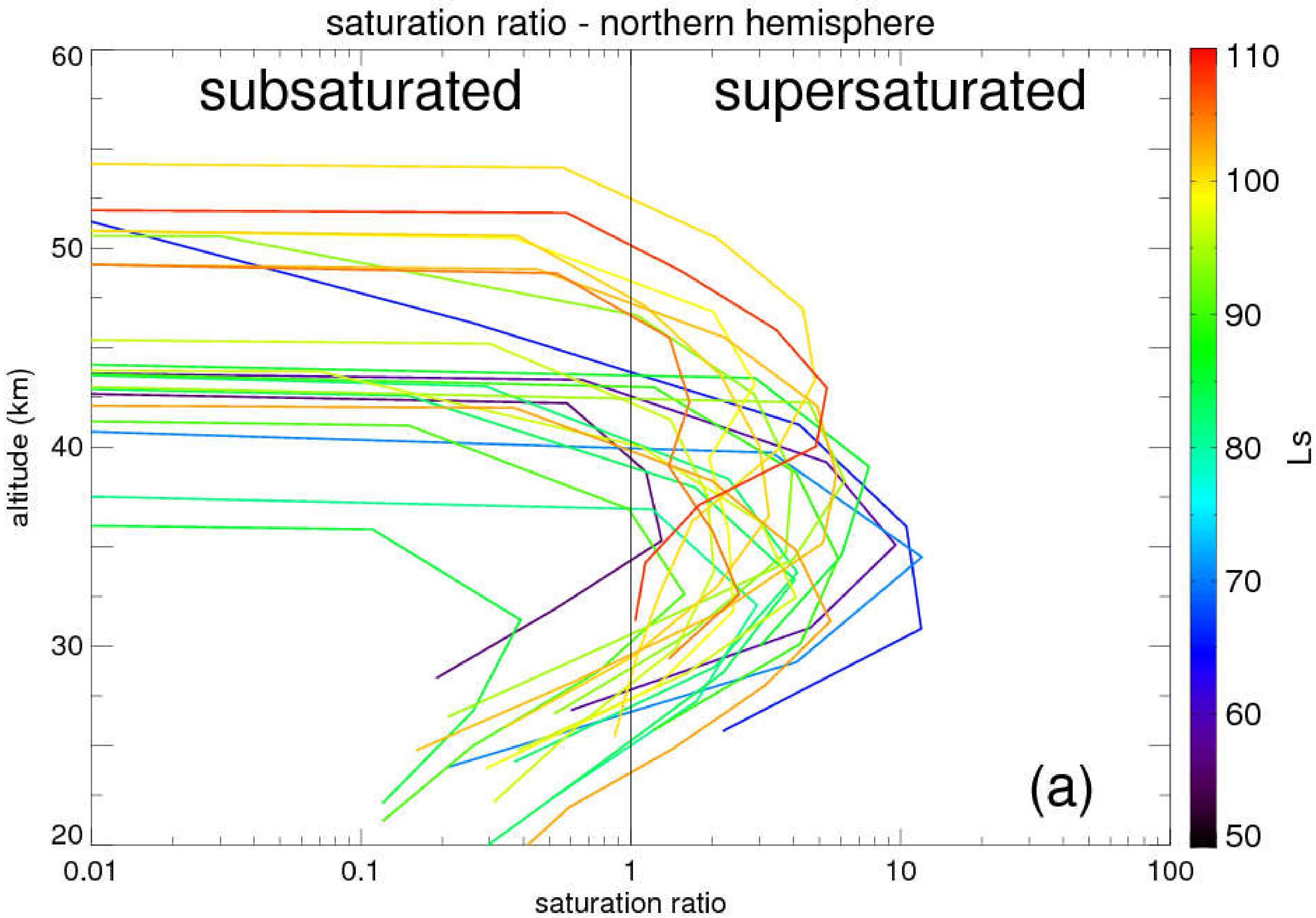
Storms at Ls~210°

Dust peak at Ls~340°


MOC-Observed Dust Storms
Courtesy of Bruce Cantor
Latitude
Ls
Mean Dust Lifting Rate
ouds
Rad. Act. Clouds
90
60
30
0
-30
-60
-90
0
60
120
180
240
300
360

Maltigliati et al. (*now in revision for Science*)
Water vapor profiles using SPICAM solar occultation measurements : Evidence of water vapor in excess of saturation.

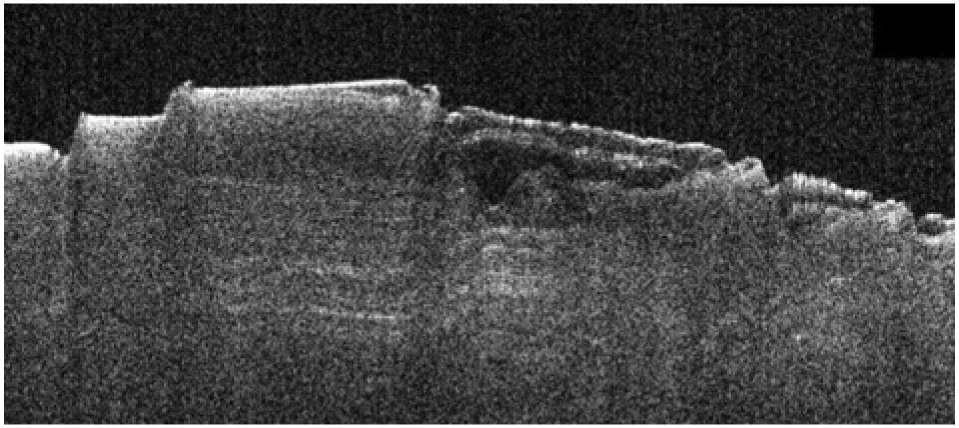


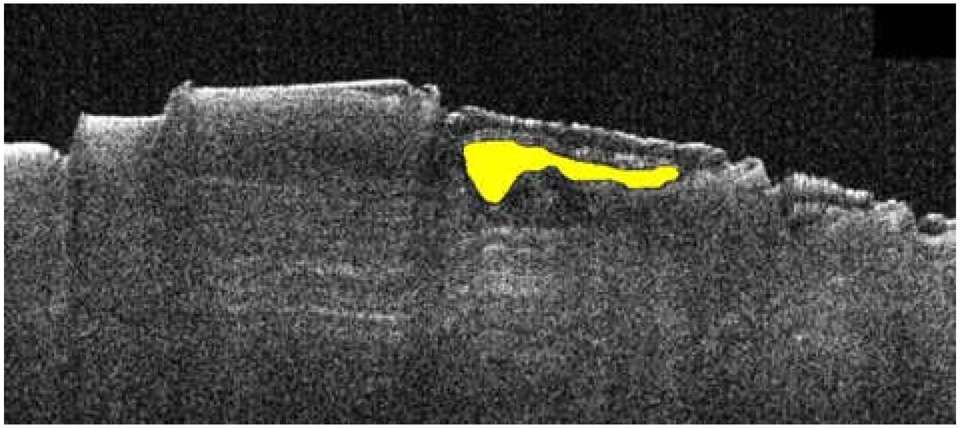


Session Recent “past climate”

Many interesting results, including the outstanding announcement of the discovery of massive CO2 ice deposits sequestered in the south polar layered deposits of Mars by Sharad

(Holt et al. ; now published in Science, Phillips et al., april 2011)





Session “Photochemistry and trace species”

- SO2 < 0.3 ppb (Encrenaz et al., Marcq et al.)
- O_2 dayglow / nightglow !
- Methane …

Sciencexpress Report

Strong Release of Methane on Mars in Northern Summer 2003

Michael J. Mumma,[1]* Geronimo L. Villanueva,[2,3] Robert E. Novak,[4] Tilak Hewagama,[3,5] Boncho P. Bonev,[2,3] Michael A. DiSanti,[3] Avi M. Mandell,[3] Michael D. Smith[3]

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nature

LETTERS

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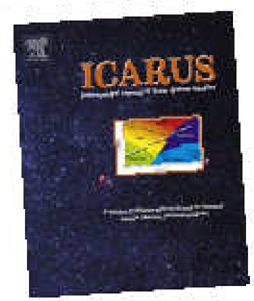
Observed variations of methane on Mars unexplained by known atmospheric chemistry and physics

Franck Lefèvre[1] & François Forget[2]

The detection of methane on Mars[1–3] has revived ... past or extant life on this planet, ... origin is thought to be ... the recent ...



Is there methane on Mars?

Kevin Zahnle[a,*], Richard S. Freedman[a], David C. Catling[b]

[a] NASA Ames Research Center, MS 245-3, Moffett Field, CA 94035, USA
[b] ... of Earth and Space Sciences, University of Washington, Seattle 98195-1310, USA

Paris 2011 Lefevre et al. : If methane is produced on Mars, how is it destroyed ? Can we explain the variations ?

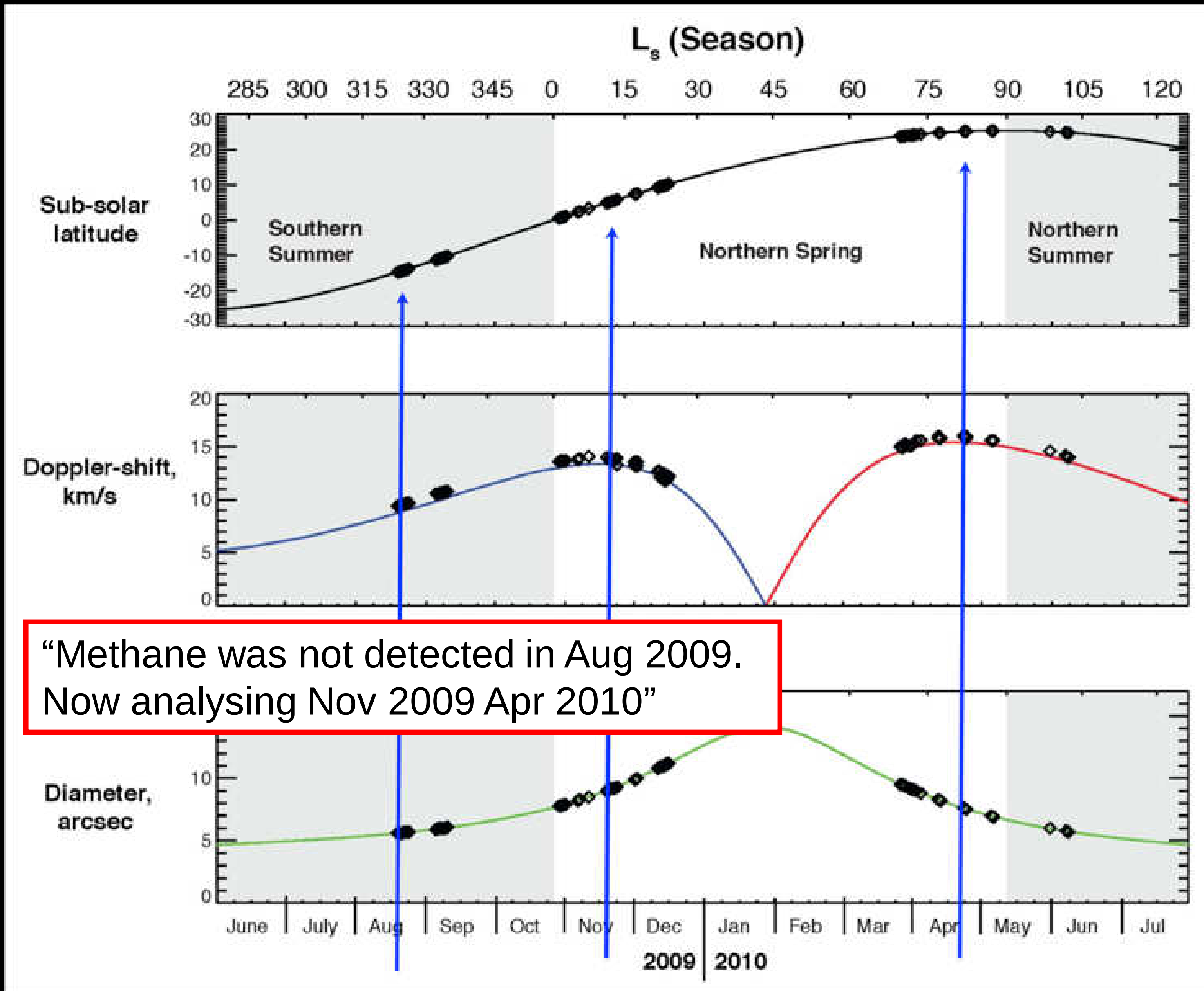
– **Photolysis**	☑	**upper atmosphere, fast (~weeks)**
– **Oxidation by OH and O(¹D)**	☑	**lower atmosphere, slow (>300 years)**
– **CH_4 + Cl → CH_3 + HCl**	☒	***Hartogh et al., 2010; this work***
– **Atmospheric loss by electrochemistry**	☒	***Atreya et al., 2007; Lefèvre and Forget*,2009**
– **Reversible adsorption in the regolith**	☒	***Gough et al., 2010; Meslin et al., 2011***
– **Irreversible destruction in the regolith (H_2O_2, ClO_4^-)**	☒	***Gough et al., 2011***
– **Trapping in polar ice (H_2O, CO_2, CO_2 clathrate)**	☒	***Trainer et al., 2010***

Mars methane

- *Lefevre et al.*
  - Observed variations of Methane remains unexplained by known chemistry and physics
  - "The quantities of CH_2O, CH_3OH, C_2H_6, C_nH_m produced by the methane degradation are too small to be detectable from Earth or by the next space missions (MSL, TGO) ⇨If detected, those species would be a strong indication of hydrocarbon production in the subsurface"..
- *Mumma et al.* :
  - No new detection since 2005, in spite of improved instruments (CRIRES/VLT ; NIRSPECS/Keck 2)

Mumma et al. 2011

Mars Observing Circumstances 2009-2010



“Methane was not detected in Aug 2009.
Now analysing Nov 2009 Apr 2010”

Mars methane

- *Lefevre et al.*
  - Observed variations of Methane remains unexplained by known chemistry and physics
  - “The quantities of CH_2O, CH_3OH, C_2H_6, C_nH_m produced by the methane degradation are too small to be detectable from Earth or by the next space missions (MSL, TGO) ⇨If detected, those species would be a strong indication of hydrocarbon production in the subsurface”..
- *Mumma et al.* :
  - No new detection since 2005, in spite of improved instruments (CRIRES/VLT ; NIRSPECS/Keck 2)
- *Observations to come*
  - Promising ground based heterodyne technique at 7.8 µm (*Stupar, Sonnabend et al*.)
  - Mars Science Laboratory : laser diode on SAM
  - Phobos Grunt: spectrometers AOST and TIMM-2 (*Korablev et al.*)
  - Trace Gas Orbiter (2016) (*TGO session with 6 presentations*)

Phobos Sample Return S/C (launch November 2011)

will observe Mars during the "observation orbit" (3 months: L_s=170–264°)

the Earth-Mars Interplanetary flight

Approach Phobos and landing

The Mars-Earth interplanetary flight

At the Phobos surface after take off the Return Module

IR Fourier Spectrometer

AOST (solar occultation and nadir)

Martian atmosphere

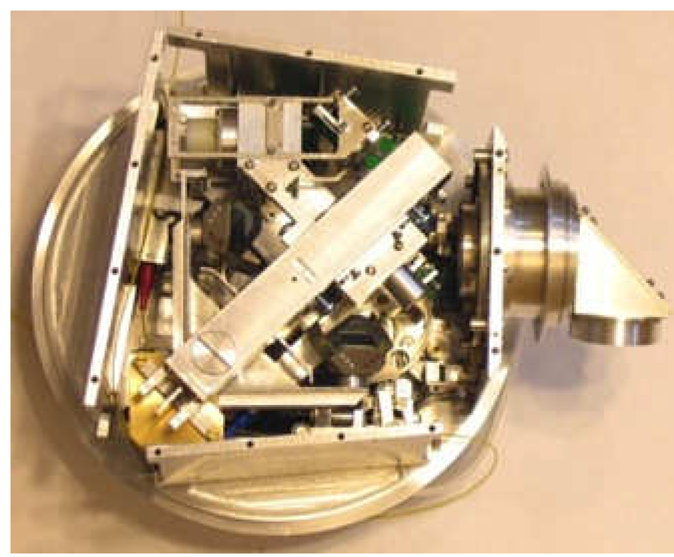
- Methane, minor constituents (by Sun occultations)
- Profiles of temperature; diurnal variations
- Monitoring of aerosols

Martian soil

- Discriminating chemically-bound and adsorbed water bands
- Diurnal variations (temperature profiles, surface frosts)

Phobos

- Global mineralogical mapping (from quasi-synchronous orbit)
- Site spectrospy at *cm*-scale (after landing)



PI: O. Korablev, IKI

Spectral range 2,5 – 25 μ

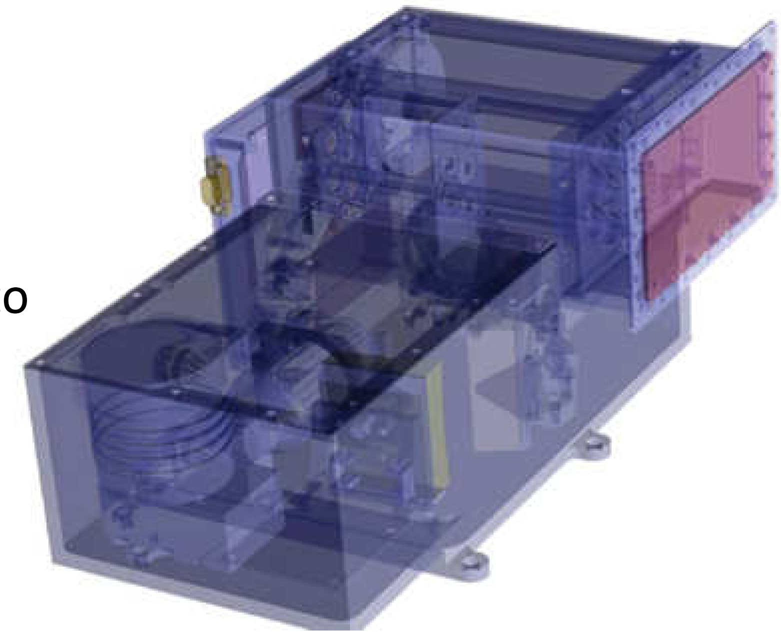
Resolution: 0.9 cm^{-1}

Field of view - 2.3 deg

Mass 4 kg

Solar occultation Echelle-AOTF Spectrometer : TIMM-2 (PI: O. Korablev, IKI)

- **2.3 µm – 4.1 µm. Spectral resolving power 20000**
- Main goal : methane detection and profiling in solar occultation
- Added to the payload after the shift of launch to 2011 (Occupies the resources of Italian TIMM (thermal IR mapping of Phobos; was not delivered)
- Recent news: Will be delivered on july 5 !



←Empty place for TIMM-2

Trying on the STM (1.02.2011) →

- Obrigado